Appendix C.
PREVIOUS EGRESS INCIDENT ACCOUNTS

C.1 INTRODUCTION

In order to identify the different factors that contribute to lives lost during emergency evacuations and how these events may have contributed to historical regulatory changes, a review was conducted of previous fires with significant loss of life that have occurred in the United States and abroad. This review was conducted under a contract to Arup Fire [45] on behalf of the NCST. In addition, past events in which evacuation efforts were successful and lives were not lost were documented.

C.2 SUMMARY OF PAST EVACUATIONS

The following steps were taken in this review:

- A literature search was conducted to identify significant fires or other incidents, with particular emphasis upon incidents in which exit geometry may have played a significant role. The search included the following sources: standard internet searches, *fire doc* searches, review of significant conference proceedings, review of journal articles and review of various handbooks.
- From the literature search, significant details of incidents were coordinated with specific NFPA 101 and model code requirements.
- Code changes from each cycle of NFPA 101: *Life Safety Code*®, the Board for the Coordination of Model Codes (BCMC), the Uniform Building Code (UBC), the BOCA Basic National Building Code (BOCA), or the Standard Building Code (SBC) were reviewed and specific changes were noted. The monographs were reviewed for each change to determine the reasons for submitting or accepting these code changes. Arup personnel visited NFPA, ICC Alabama, ICC Chicago, and ICC Los Angeles libraries to review historic codes and monographs.
- Code change dates were matched to significant fire dates, and where possible, code changes precipitated by large life loss fires were identified.

C.2.1 Unsuccessful Evacuation

Table C-1 provides a summary of the unsuccessful incidents. The contributing factors listed in the table were identified as possible links to code changes that followed the incident. Contributing factors flagged were the following: delayed notification, combustible interior finishes, some exits blocked or not obvious, incorrect exit door swings, locked exit doors, inadequate exit capacity, barred or boarded windows, and crowd crush at exits.

Delayed notification was considered a contributing factor if the incident reports specifically stated this fact. Combustible interior finishes were considered a contributing factor if it was mentioned in the sources that combustible finishes were located on the walls, ceilings, or structure. Combustible finishes were not considered a contributing factor if a large amount of combustibles were present, but finishes were noncombustible. Blocked or concealed exits were considered a contributing factor if it was found in

the literature that the exits were blocked by fire, blocked by building contents, or if they were concealed or hidden by building contents, furnishings, or layout.

If the literature stated that the building had incorrect exit door swings, this was considered a contributing factor. Locked exits were considered a factor if it was stated in the reports that doors were locked or were difficult to open to unfamiliar occupants. If the incident reports stated that there was inadequate exit capacity, or this could be inferred by the situation then this was considered a contributing factor. If a building was overcrowded and could otherwise accommodate the number of occupants specified by the building code, inadequate exit capacity was still considered a factor. If the reports stated that the windows were barred or boarded and the windows could otherwise be considered a means of escape, this was considered a contributing factor. If the incident accounts included descriptions of occupants piling-up at the exit doors, and thus hindering evacuation, crowd crush at the exits was considered a contributing factor.

Table C-2 provides additional details regarding these incidents, as well as an overview of any regulatory changes brought about as a result and any efforts to analytically model each incident. Note that the regulatory changes listed in Table C-2 are not necessarily directly related to the specific incident, but rather, the changes listed indicate modifications to the subsequent revision of the particular regulation.

C.2.2 Successful Evacuations

Table C-3 is set up similarly to Table C-1, except that it lists factors that may have contributed to a successful evacuation.

C.3 DETAILS OF UNSUCCESSFUL INCIDENTS

C.3.1 Conway's Theater Fire, Brooklyn, NY, 1876

On December 5, 1876, during the final act of the play *The Two Orphans*, a fire erupted in Conway's Theater [1]. The theater seated 1700, but held 800 at the time of the fire. The rising velvet curtain created a draft that caught a gas jet flame. The flame ignited a flimsy drape and spread quickly. The audience saw the fire spreading out from around the stage before the actors on stage knew what was happening. A member of the company in the wings alerted the actors. Three actors stood at the front of the stage and told the audience to stay calm. Some people even sat back in their seats when they heard this.

The theater construction included a cheap wooden bench gallery; this gallery collapsed, throwing 150 audience members into the fire below. This also led to further fire spread into the theater. Stagehands were trying to put out the fire with canvas, since there was no fire fighting equipment available. The stagehands stopped attempts to extinguish the fire after the collapse of the gallery.

The stage manager ordered everyone on stage to save themselves; some actors escaped through the stage door to an adjoining alley or through the cellars under the stage, which opened through horizontal grates to the street. All of the people in the theater company escaped except for the three actors that stood at the front of the stage to calm the audience during the beginning stages of the fire. Many of the audience members were crushed to death in the obstructed, narrow, winding stairs of the main exit. In addition, many perished in the cellar. However, since the fire department had no way of knowing the occupant load of the theater at the time of the fire, and since a significant number people made it out of the building safely, the firefighters thought that all had been saved and started trying to prevent the fire from spreading to other buildings. In all, 315 lives were lost in the Conway's Theater fire.

Table C-1. Historical Review of Incidents: Data and Contributing Factors

Facility Name	INCIDENT DATA									CONTRIBUTING FACTORS								
	Year	Type of Occupancy	Type of Incident	Fatalities	Occupants at Time of Fire	Occupants Allowed by Code	Fire Origin	Sprinkler System Present	Alarm System Present	Delayed Notification	Combustible Interior Finishes	Some Exits Blocked or not Obvious	Incorrect Exit Door Swings	Locked Exit Doors	Inadequate Exit Capacity	Barred or Boarded Windows	Crush at Exits
Conway's Theater [1]	1876	Assembly	Fire	315	800	1700	Gas Jet Flame				✓	✓			✓		✓
Iroquois Theater [2, 3]	1903	Assembly	Fire	602	~2400		Hot Light			✓	✓	✓		✓	✓		✓
Lakeview Elementary School [4]	1908	Educational	Fire	174	~400		Overheated Steam Pipe		✓		✓	✓					✓
Triangle Shirtwaist [5]	1911	Factory	Fire	147	~500		Rag Bin			✓			✓	✓	✓		✓
Italian Hall [5, 6]	1913	Assembly	False Alarm / Prank	72			No Fire						✓		✓		✓
Clinic [7, 8]	1929	Hospital	Fire	123	~250		X-Ray Film Ignited			✓							✓
Rhythm Club [9]	1940	Assembly	Fire	207	700+		Food Grill				✓	✓	✓		✓	✓	✓
Cocoanut Grove [5, 10]	1942	Assembly	Fire	492	~1000	600	Unknown				✓	✓	✓	✓	✓		✓
Winecoff Hotel [11, 12, 13]	1946	Hotel	Fire	119	280		Accident (suspicious)			✓		✓			✓		
Our Lady of Angels [5]	1958	Education	Fire	93			Unknown		✓	✓	✓	✓			✓		
Upstairs Lounge [14]	1973	Assembly	Fire	32	65	110	Arson				✓	✓		✓	✓	✓	
Gulliver's Disco [15]	1974	Assembly /Mixed	Fire	24	~500		Arson			✓		✓			✓		
Beverly Hills Supper Club [3, 5, 16]	1977	Assembly	Fire	164	2400-2800	1511	Electrical			✓	✓	✓		✓	✓		✓

Facility Name	INCIDENT DATA									CONTRIBUTING FACTORS								
	Year	Type of Occupancy	Type of Incident	Fatalities	Occupants at Time of Fire	Occupants Allowed by Code	Fire Origin	Sprinkler System Present	Alarm System Present	Delayed Notification	Combustible Interior Finishes	Some Exits Blocked or not Obvious	Incorrect Exit Door Swings	Locked Exit Doors	Inadequate Exit Capacity	Barred or Boarded Windows	Crush at Exits
The Who Concert [3, 17]	1979	Assembly	Crowd Ingress	11	~8000		No Fire							✓	✓		✓
Haunted Castle [18]	1984	Amuse-ment park	Fire	8	~30		Accident				✓	✓					
Happy Land Social Club [20, 21]	1990	Assembly	Fire	87			Arson	✓*			✓	✓		✓	✓		
Private Club [22]	1992	Assembly/ Hotel	Fire	3			Accident		✓		✓						
E2 Nightclub [23, 24, 25]	2003	Assembly	Crowd Egress	21	~500	240-300	No Fire					✓		✓	✓		✓
Summerland [26]	1973	Assembly	Fire	51	~3000		Accident			✓	✓			✓	✓		✓
Stardust Cabaret [27]	1981	Assembly	Fire	48	846		Arson				✓						
Gothenburg Dance Hall [28]	1998	Assembly	Fire	63	~400	150	Arson				✓	✓			✓		✓
de Hemel [45]	2000	Assembly	Fire	14			Accident				✓	✓					

*Sprinkler or alarm covered only a portion of the building, or system was not operational (see Table C-2 for details).

Table C-2. Historical Review of Incidents: Additional Details, Regulatory Changes, and Modeling

Facility Name	Year	Deaths	Crowd Crush	Additional Details	Resulting Regulatory Changes	Modeling Information
Conway's Theater [1]	1876	315	✓	No basic fire fighting equip. in bldg. Wooden bench gallery collapse causing fire spread. Narrow, winding exit stairs. Firefighting efforts focused on surrounding exposures.		
Iroquois Theater [2, 3]	1903	602	✓	No fire hoses and extinguishers. Stage fire curtain failed to completely close. Occupants informed to remain seated. Exit doors covered by metal gates. Exits converged in a common stairway.		
Lakeview Element. School [4]	1908	174	✓	Fire under wooden exit prevented stair usage. Floor collapsed into fire below. Non-isolated stairways. Delayed response by fire department.		
Triangle Shirtwaist [5]	1911	147	✓	Combustible construction and interior finishes. High fuel loads of hanging, piled cloth. Exit doors were locked and swung in the opposite direction of travel. Fire escape collapsed.	***NFPA 101®:*** Creation of a Committee on Safety, a Factory Investigating Commission, New York Fire Prevention Bureau and the NFPA Building Exiting Code (Life Safety Code).	
Italian Hall [5, 6]	1913	72	✓	No fire, unknown mass evacuation. Single stair for egress. Inward swinging doors.		
Clinic [7, 8]	1929	123	✓	Some X-rays were stored outside of metal cabinets. Two explosions produced poisonous gasses that killed nearly all victims. Toxic gases were spread by the ventilation system and open fire door.		
Rhythm Club [9]	1940	207	✓	Dry moss suspended from ceiling. One available exit, windows were boarded up. No upper windows or skylights to vent heat, smoke.		

Facility Name	Year	Deaths	Crowd Crush	Additional Details	Resulting Regulatory Changes	Modeling Information
Cocoanut Grove [5, 10]	1942	492	✓	Highly overcrowded as compared to codes. Combustible decorations placed throughout. Exits hidden by decorations, many were locked. Narrow hallways and converging exits. Jammed revolving entrance door.	***NFPA 101®:*** Greater acceptance of Building Exits Code; clarification of exit requirements; limitation noted concerning use of combustible finishes.	CFAST, WPI/Fire used to model fire effects within bldg. FPETool was used to estimate available evacuation time, sprinkler activation if sprinklers had been present.
Winecoff Hotel [11,12,13]	1946	119		No fire escapes or sprinklers. Delayed notification to fire department. Open main central staircase allowed flame and smoke to spread. Fire doors were not used. Transoms were not all air sealed.		
Our Lady of Angels [5]	1958	93		2 of the 5 available stairways were enclosed. Combustible materials were located in the stair. Delayed notification due to teachers evacuating their own classes. Inadequate opening protection.	***NFPA 101®:*** Improved fire safety procedures; tests were conducted to explore multistory school building with open stairs; requirement of sprinklers in school bldgs of different type. ***BOCA:*** Changes were made to the classification of the interior finishes requirements.	
Upstairs Lounge [14]	1973	32		Rapid fire spread in only stair due to combustible interior finishes. Fire door at the top of the stairs was opened and lead to smoke spread. Hidden and obstructed rear exit door. Numerous windows were boarded up or equipped with steel bars.	***BOCA:*** Increases to egress capacity, travel distance; panic hardware was required for >100 occupants; widely requirement of sprinklers and standpipes	
Gulliver's Disco [15]	1974	24		Delayed discovery of the fire. Lack of fire-rated doors and wall separations. Exits were not separated Exits from dance floor were not remote and one stairway was blocked by smoke.	***NFPA 101®:*** Requirement for fire alarm/notification systems be installed with loads >300. ***BOCA:*** Increases to egress capacities of travel distances, doors and stairs; panic hardware for >100 occupants; sprinkler systems and standpipes were more widely required.	

Facility Name	Year	Deaths	Crowd Crush	Additional Details	Resulting Regulatory Changes	Modeling Information
Beverly Hills Supper Club [3, 5, 16]	1977	164	✓	Number of occupants greater than the applicable codes Overcrowded room with tables and additional seating which blocked egress movement Rapid fire spread due to combustible interior finishes Delayed movement time No alarm system was installed in the building	***NFPA 101®:*** Although not necessarily directly related to this incident, the 1981 Edition required fire alarm and automatic sprinkler systems in assemblies > 300 persons. ***BOCA:*** Doors were to be installed with panic hardware and swing in the direction of travel for loads of >50 occupants.	A resistor network diagram and mean flow volume equations showed that opening doors drew the fire into the escape routes.
The Who Concert [3, 17]	1979	11	✓	Poor crowd management plan Only one of two doors were open to allow the 8000 concert goers to enter the building	***NFPA 101®:*** Requirements regarding festival type seating were introduced. Crowd Management report that offered 108 safety recommendations was developed.	
Haunted Castle [18]	1984	8		No automatic detection or suppression system installed. Large amounts of combustible materials were present. Foam plastic mounted on walls. Occupants had difficulty escaping.	***NFPA 101®:*** Limits placed on use of types of interior finishes. ***BCMC:*** Size, location and illumination of exit signs. ***UBC:*** Interior finish requirements were changed	
Happy Land Social Club [20, 21]	1990	87		Building violated code regulations but still in operation. Building was only partially sprinklered. One of the two main exit doors was covered by a roll-down steel security door, swinging doors were locked. Four doors separated the patron areas from an entrance lobby. Exit stairs were not enclosed. Combustible interior finishes in lobby area.	***UBC:*** Although not necessarily a direct result of this incident, changes were made to the requirements of exit width and fire alarm/notification system for the subsequent edition.	
Private Club [22]	1992	3		Lack of approved sprinkler and unprotected penetrations in walls, ceiling assemblies contributed to spread. Concealed spaces increased hazard for firefighters. Wood paneling on walls, ceiling tiles left in concealed spaces contributed to fire extent	***BOCA:*** Sprinklers were being required in assembly occupancies of various sizes.	

Facility Name	Year	Deaths	Crowd Crush	Additional Details	Resulting Regulatory Changes	Modeling Information
E2 Nightclub [23, 24, 25]	2003	21	✓	Club should have been closed due to numerous building code violations. Pepper spray caused the crowd to rush the main exit. Alternate exits not easily accessible. The club was overcrowded.	Since this fire is so recent there have not been any regulatory changes.	
Summer-land [26]	1973	51	✓	Delayed notification to fire service. Combustible exterior and interior finishes aided in fire spread. Emergency doors were padlocked. Turnstiles could not handle numbers.	Isle of Man and the United Kingdom tightened fire regulations on public buildings.	
Stardust Cabaret [27]	1981	48		Adequate exit capacity. Fire spread quickly due of large amount of combustible materials.	Fire investigation lead to significant range of recommendations but unknown if that lead to changes in regs.	
Gothen-burg Dance Hall [28]	1998	63	✓	Fire growth and spread was high due to fuel loads. Hall was severely overcrowded. No automatic detection or sprinkler system was installed. Occupant that first discovered fire did not notify others. Numerous people jumped from windows. Crowds of people surrounding the building hampered the fire service.	Discussions concerning the use of multiple "normal" exits would be better than a fewer wider exits for public halls/auditoria were conducted.	BuildingEXODUS evacuation model used to analyze similar scenario (fire load used in model was main difference). [29]
de Hemel nightclub	2000	14		New Years eve, 2000/2001, Fire spread over Christmas tree boughs suspended from ceiling, ignited accidentally with a sparkler		Fire recreated at TNO laboratory

Table C-3.Table 5-1. Historical Review of Incidents: Successful Evacuations

Incident	Year	Fire Origin	Manual Alarm	Detection System	Sprinklers	Occupants	Fatalities	Occupant Injuries	Delayed Evacuation	Delayed FD Response	Fire Contained by Construction
School, California [30]	1992	Cooking equipment	✓	✓		1,000	0	0	✓		
Nightclub, Texas [31]	1992	Electrical			✓	100's	0	0			
School, Oregon [32]	1992	Arson	✓		✓[2]	450	0	0			✓
School, Mass. [33]	1992	Pyrotechnic device					0	0		✓	
School, Oregon [34]	1994	Electrical		✓			0	0			
Restaurant, Indiana [35]	1996	Cooking equipment			✓[3]		0	0			
Dinner Theater, Florida [36]	1996	Pyrotechnic device	✓	✓	✓	400	0	0			
Restaurant, Michigan [37]	1996	Equipment malfunction					0	0			
Community Cntr, Penn. [38]	1997	Electrical	✓	✓	✓[2]	100	0	4			
Restaurant, Massachusetts [39]	1997	Cooking equipment			✓[2,3]	25	0	0			
School, California [40]	1998	Electrical	✓[1]				0	0	✓	✓	
Casino, Nevada [41]	1998	Unknown		✓	✓		0	1			✓
Restaurant, New Jersey [41]	1998	Smoking materials		✓	✓[2]		0	2			
Restaurant, Michigan [41]	1998	Cooking equipment			✓[3]		0	0			
Theater, Nevada [42]	1999	Electrical			✓		0	5			
Fine Line Music Café, Minneapolis [43]	2003	Pyrotechnic device			✓	120	0	0			

[1] Manual alarm system out of service at time of fire.
[2] Sprinkler system covered only part of the building.
[3] Kitchen area protected by dry chemical extinguishment system.

The following details regarding this incident are of note:

- The theater did not have the basic fire fighting equipment, including a hose or any water buckets, because it was believed that a brick building would not burn;
- The wooden bench gallery collapsed, killing many audience members and spreading the fire beyond the stage;
- The main exit was at the bottom of narrow, winding stairs, which were eventually blocked by bodies that had fallen in the evacuation push;
- Fire fighters thought that everyone had made it safely out of the building and concentrated on saving the surrounding buildings.

Impact on regulations or practices

The NFPA Life Safety Code, the Board for the Coordination of Model Codes (BCMC), the Uniform Building Code (UBC), the BOCA Building Code (BOCA), and the Standard Building Code (SBC) had not yet been developed at the time of the fire.

C.3.2 Iroquois Theater Fire, Chicago, Illinois, 1903

Less than one month after its grand opening, the Iroquois Theater in Chicago, Illinois suffered a fast-moving fire during a performance [2,3]. At 3:15 PM, a hot light ignited highly combustible stage scenery items. The fire spread rapidly, and the efforts of the lone on-duty firefighter proved futile. Contrary to standard precautions in theaters at the time, the Iroquois Theater had no fire hoses or extinguishers and the standpipes on the stage were dry because the water supply system was not completed. Confident that the fire could be controlled, an actor urged the audience to remain seated. However, the fire rapidly escalated, and people eventually began moving. Numerous deaths occurred as people from the balcony level, the gallery level, and the main level converged in the exit stairway. Additionally, numerous people jumped from the upper levels as the stairway became blocked.

All 602 deaths occurred within 15 minutes of the start of the fire. Most of the fatalities were in the third floor or gallery area. A draft caused by the stage exit doors being opened caused flames to rush to open vents above the gallery rather than to the stage vents, which were missing counterweights and were nailed shut. Upon arrival, fire department personnel were able to extinguish the fire within 30 minutes. The building was largely undamaged, and reopened within one year.

The following details regarding this incident are of note:

- The theater lacked fire hoses and extinguishers, so the on-duty firefighter was not able to fight the fire above his head;
- The ushers and personnel received no instructions about what to do in the case of a fire;
- The curtain designed to separate the stage area from the audience got caught before it could reach its full down position, and thus was unable to prevent fire spread from the stage. Later testimony revealed that the curtain may have been improperly installed, and also may not have been fireproof;

- After the fire started, the audience was urged to stay in their seats and not to evacuate, and the orchestra continued playing;
- Some exit doors had been covered by metal gates. Some of these were locked, and others had latches that were likely unfamiliar to occupants;
- Exit paths from the balcony area and the main floor met in a single, common stairwell.

Impact on Regulation or Practices

The NFPA Life Safety Code, the Board for the Coordination of Model Codes (BCMC), the Uniform Building Code (UBC), the BOCA Building Code (BOCA), or the Standard Building Code (SBC) had not yet been developed at the time of the fire.

C.3.3 Lakeview Elementary School Fire, Collinwood, Ohio, 1908

The Lakeview Elementary School fire was the worst disaster in Cleveland history with a toll of 172 children and two teachers [4]. The three-story school had a brick exterior, but the interior was all constructed of wood. It was theorized at the time that the fire was caused by an overheated steam pipe that ignited wood joists under the front stairs. The fire was discovered by a child who had gone down to the girls' lavatory in the basement. The student told the janitor who then sounded the alarm and opened the front and rear doors. Students that attempted to escape using the front doors were pushed back by flames and smoke, so they ran to the back entrance. Someone fell at the back entrance and a blockage of people developed as many tried to force their way through. One of the exterior doors had blown shut and children became wedged in the narrow space. The pushing of the students trying to escape and the weakening of the structure by the fire below caused the floor to collapse, which plunged the crowd into the burning basement. Classes on upper floors fled using fire escapes and others jumped out of windows. The team of village horses used by the volunteer fire department was busy dragging a road scraper a mile away, so by the time they arrived little could be done.

The following details regarding this incident are of note:

- Wooden construction ignited under the front stairs, rendering them useless for evacuation;
- The floor at the rear exit collapsed, throwing many occupants into the fire;
- Stairways were not enclosed;
- Exterior rear door blew shut;
- The team of horses that normally pulled the fire engine were not readily available at the time of the fire and arrived late to the scene.

Impact on regulations or practices

The fire in Collinwood brought about laws requiring fire resistant construction, enclosed stairwells, and "panic bars" that trigger door latches when pushed from inside in schools. The NFPA 101 Life Safety Code, the Board for the Coordination of Model Codes (BCMC), the Uniform Building Code (UBC), the BOCA Building Code (BOCA), or the Standard Building Code (SBC) had not yet been developed at the time of the fire.

C.3.4 Triangle Shirtwaist Company Fire, New York, New York, 1911

The fire at the Triangle Shirtwaist Company in New York in 1911 had possibly the greatest impact on modern fire and life safety codes of any historical fire. The business was located on the three topmost floors of a ten-story wood-framed building. Fire initiated in a bin of rags on the lowest of the three floors, and quickly spread despite the efforts of employees to extinguish it using buckets of water [5]. Large amounts of fabric throughout the space contributed to rapid fire growth and spread.

Initial evacuation was hampered by a locked exit door, which, when eventually unlocked, swung against the direction of egress travel, thus causing a crush of evacuating occupants. Even after the door was opened, some occupants tripped on the exit stairway and caused a further delay in the egress.

Some occupants from the top floor escaped via the roof to an adjacent building. Occupants of the upper and lower floors never notified the middle floor occupants of the fire. Instead, occupants of this floor learned of the fire when flames extended through the windows. During the exiting of occupants from this floor, the fire escape collapsed. Some occupants tried to use the elevators, but they were already packed with occupants from other floors. As a last resort, some occupants jumped from the ninth-floor windows. A total of 147 people died in this incident.

The following details regarding this incident are of note:

- The building was of combustible wood construction with combustible interior finishes. The New York City building codes of the time allowed this for structures less than 11 stories high;
- Each of the two lower floors, where large numbers of employees worked, included vast amounts of cloth either piled on the floors, in bins or on tables, or hanging from lines. This contributed to rapid fire growth and spread on the floor of origin;
- Numerous exit doors were locked in an effort to monitor employees and prevent theft;
- The exit doors swung opposite the direction of egress travel;
- The building had only two staircases. This violated New York City building codes of the time, which required three staircases per floor where the floor area of each floor exceeded 10,000 ft²;
- Elevators placed priority on the topmost floor, and thus were full when they stopped at the lower floors, where the danger was more imminent;
- A lack of communication between the eighth and tenth floors and the ninth floor led to late notification of the occupants of the ninth floor;
- The fire escape, when heated by the fire extending from the windows, could not support the large number of evacuating occupants and collapsed;
- The New York City fire department did not have equipment that could fight fires higher then seven stories up in a given building.

Impact on regulation or practices

According to information in the Life Safety Code® Handbook:

- Immediately after the incident, New York City residents formed the Committee on Safety, which worked to pass laws requiring greater safety in factory buildings;

- The Governor of New York, in response to this incident, created a Factory Investigating Commission within the state;
- Later in the same year, a law was passed creating the New York City Fire Prevention Bureau (the first such bureau in the US).

NFPA 101®: Life Safety Code®

Again, according to the Life Safety Code Handbook, due to the severity of this incident, NFPA began to broaden its scope to include elements of life safety. The first such publication dealt with exit drills in factories, schools, department stores, and theaters. Two years later, an NFPA committee on Safety to Life, which was to study the current situation regarding life safety in buildings, was formed. This was the beginning of the NFPA Life Safety Code. In 1927, this work also resulted in the NFPA Building Exiting Code.

Board for the Coordination of Model Codes (BCMC)
The earliest BCMC reports obtained were from 1977; therefore, information on changes prior to 1977 was not available.
Uniform Building Code (UBC)
The first edition of the UBC was not published until 1927.
BOCA Building Code (BOCA)
The first edition of the BOCA code was not published until 1950.
Standard Building Code (SBC)
The first edition of the SBC was not published until 1945. Details of proposed changes and committee reports were not available prior to 1977.

C.3.5 Italian Hall Disaster, Calumet, Michigan, 1913

On Christmas Eve of 1913, a party was being held in an upstairs function room in the Italian Hall in Calumet, Michigan. The majority of the attendees were children. At some point during the party, something caused the occupants to initiate a mass evacuation. Reports of the cause of this vary, but no fire was found [5,6]. The evacuating occupants rushed down the main stairway and clogged in the exit doorway. The resulting crush of people in the stairwell led to the deaths of 72 people; all of these were either crushed or suffocated.

Some reports indicate that intoxicated, disgruntled workers may have yelled 'fire.' It is unclear if this did occur.

The following details regarding this incident are of note:

- The function room was served by a single main exit stairway;
- The exit doors at the bottom of the main stairwell opened inward; this resulted in a blockage as people rushed down the stairway before the first evacuating occupants could open the doors.

Impact on regulation or practices

NFPA 101®: Building Exits Code®

NFPA 101 was not yet published; the incident occurred in 1913 while the first edition of the *Building Exits Code* was released in 1927.

Board for the Coordination of Model Codes (BCMC)

The earliest BCMC reports obtained were from 1977; therefore, information on changes prior to 1977 was not available.

Uniform Building Code (UBC)
The first edition of the UBC was not published until 1927.

BOCA Building Code (BOCA)
The first edition of the BOCA code was not published until 1950.

Standard Building Code (SBC)

The first edition of the SBC was not published until 1945. Details of proposed changes and committee reports were not available prior to 1977.

C.3.6 Clinic Fire, Cleveland, Ohio, 1929

On May 15th, 1929 a fire started at 11:25 AM in a basement room where 70,000 X-rays were stored [7,8]. The burning films released poisonous gases that traveled through the building's ventilation system that was also located in the basement. A fire door was left open aiding in the movement of the poison gas. At 11:31 AM, an explosion rocked the building, spreading more poisonous gas and starting fires throughout the building. When the fire department arrived, the building was already shrouded in smoke. Soon after, another explosion shook the building. Patients ran for the exits, and many succumbed to the toxic gases while trapped in stairways and near the elevator. Many of the nurses and doctors died helping the patients. Some patients found their way out, but eyewitness accounts state that many of these perished as a result of their injuries or inhalation of smoke. The fires were extinguished, and the victims were removed from the building within two hours. The incident claimed 123 lives; 43 of these were doctors and nurses. Nearly all of the victims died of inhalation of poison gas.

The following details regarding this incident are of note:

- Contrary to American Hospital Association guidelines, the X-rays were stored in paper folders and some had been left outside the steel cabinets where they were supposed to be kept;
- A fire door was open and allowed the gas to spread throughout the clinic;
- The building was not equipped with a sprinkler system.

Impact on regulation or practices

The fire resulted in the development of new standards for the storage of hazardous materials, particularly X-ray film. Also, poisonous gases were recognized as a hazard and fire insurance companies began to develop and strictly enforce safety regulations.

The impacts that this incident had on various regulations are discussed below.

NFPA 101®: Building Exits Code

While there do not appear to be any changes to NFPA 101 directly associated with this incident, the 1929 edition brought the first introduction of the "Assembly Occupancies" chapter. The 1934 edition expanded upon occupant loading, exit capacities, required number of exits, and travel distances.

Board for the Coordination of Model Codes (BCMC)

The earliest BCMC reports obtained were from 1977; therefore, information on changes prior to 1977 was not available.

Uniform Building Code (UBC)
There do not appear to be any changes to the UBC directly related to this incident.

BOCA Building Code (BOCA)
The first edition of the BOCA code was not published until 1950.

Standard Building Code (SBC)

The first edition of the SBC was not published until 1945. Details of proposed changes and committee reports were not available prior to 1977.

C.3.7 Rhythm Club Fire, Natchez, Mississippi, 1940

The Rhythm Club was a single-story dance hall in Natchez, Mississippi. It was a wood framed building with corrugated steel walls and roof. Several years before the fire, the ceiling joists of the building had been concealed by adding a layer of Spanish moss on top of a netting system. On the night of the fire, the moss was extremely dry; it is suspected that the heat from a grill located near the front of the building caused the moss to ignite. The fire spread rapidly across the dry moss [9].

The building was equipped with only one exit, which was located at the front of the building. When the fire began to grow, several occupants were able to exit through this door. However, the location of the ignition near the front of the building caused most of the occupants to move to the back into the building, where there were no additional exits. The main exit doors opened against the direction of egress travel, but since only a few people were able to reach this exit, it was not expected that this detail significantly contributed to the loss of life, and no fatalities occurred near these doors. The sides of the building were lined with numerous small windows, but all of these in the main open portion of the building had shutters, some of which were latched, but most of which were nailed closed. All of the shutters opened inward. As a last resort, occupants attempted to break through the corrugated steel walls of the building to reach the outside, but were unsuccessful. The majority of the 207 fatalities occurred at the very back of the building, at the opposite end from the only available exit.

The following details regarding this incident are of note:

- The tinder-dry Spanish moss layered below the ceiling joists led to extremely fast fire spread along the length of the building, and contributed to further fire spread by falling and igniting combustible items below;
- The building was equipped with only one available exit door. The location of the fire in the front portion of the building prevented most occupants from accessing this exit;
- None of the windows along the sides of the main portion of the building could be used as a means of escape, since they were very small and most were boarded up. One plain glass window was included in a subdivided portion at the front of the building, but occupants were not able to reach this area due to the location of the fire, and even if they had, the door to this room was locked;
- At the time of the fire, more than 700 people were packed into the 120 ft by 38 ft structure;

- There were no skylights or other windows to vent the heat or smoke, so the metal walls held the heat in like an oven.

Impact on Regulation or Practices

NFPA 101®: Building Exits Code®
There do not appear to be any changes to NFPA 101 directly associated with this incident.

Board for the Coordination of Model Codes (BCMC)
The earliest BCMC reports obtained were from 1977; therefore, information on changes prior to 1977 was not available.

Uniform Building Code (UBC)
There do not appear to be any changes to the UBC directly related to this incident.

BOCA Building Code (BOCA)
The first edition of the BOCA code was not published until 1950.

Standard Building Code (SBC)

The first edition of the SBC was not published until 1945. Details of proposed changes and committee reports were not available prior to 1977.

C.3.8 Cocoanut Grove Nightclub Fire, Boston, Massachusetts, 1942

The Cocoanut Grove Nightclub was a single-story building with a finished basement. The basement contained an additional lounge and a kitchen. Technically, the capacity of the club was 600 occupants. On the night of November 28, 1942, when a fire broke out in some combustible decorations in the basement lounge, there were over 1000 occupants in the club [5,10]. From the portion of the building where the fire broke out, there was only one obvious exit, and this was up a set of stairs leading through an approved exit door to a hallway, and eventually to the main exit, which included a revolving door. This hallway also had a door exiting to the street, but this was locked at the time of the fire. Other means of egress existed, but were concealed behind decorations and false walls; some were locked.

The fire spread rapidly across the underside of the false ceiling in the compartment of origin, and eventually went up the exit stairs and into the exit hallway and spread into the main dining room. The patrons in the main dining area knew of only one exit, the main exit with the revolving door. Other exits were not obvious or were hidden with decorations similar to the basement lounge. Some of the patrons stumbled upon these exits and escaped; however, some of the exits on the first floor were also locked trapping occupants.

There was a second lounge area on the first floor down a narrow hallway from the dining area. The smoke spread into this area and people rushed for the only exit door, which opened inward. The push of the crowd jammed the door closed and many of the occupants within this area died.

It is reported that the fire lasted less than an hour from ignition to extinguishment; 492 people died. Many of these deaths resulted from a bottleneck of evacuating occupants in the narrow exit hallway leading from the downstairs lounge. Many more people died when they got trapped behind the revolving door that served as the main exit from the lobby area.

The following details regarding this incident are of note:

- The night of the fire, the club was highly overcrowded (compared to its capacity according to the applicable codes);
- The fire spread rapidly across combustible decorations throughout the club;
- While numerous exits from the lower-floor lounge existed, only one was obvious and unlocked the night of the fire. Others were hidden by decorations or false walls, and many of these were locked. Only employees, and the few people the employees were able to assist, used these exits;
- The main exit from the lower lounge required that occupants traverse a narrow hallway and enter the main lobby, where they would converge with occupants evacuating from other parts of the building. An additional exit door located in the narrow hall was locked;
- Many of the patrons in the dining area only knew of the main exit, since many of the other exits were concealed or unmarked;
- Some of the exits were locked;
- The only exit in the smaller lounge off from the dining area opened inward and trapped patrons in the lounge;
- A large number of people were trapped behind the revolving main entrance door, which became jammed with people early in the evacuation.

Impact on Regulation or Practices

NFPA 101®: Building Exits Code®

According to information in the Life Safety Code® Handbook:

- Subsequent to this incident, the NFPA Building Exits Code began to be accepted by more jurisdictions throughout the country;
- At the 1945 NFPA Annual Meeting, the Committee on Safety to Life recommended changes to the prescribed method of egress capacity measurement, clarification of stairway enclosure requirements, changes to requirements regarding moveable chairs in nightclubs, and changes in exit lighting and signage requirements, as a result of this fire;
- A caution was added to the Building Exits Code warning that, where combustible interior finishes exceeding the limitations of the Code were used, the provisions of the Code may not be sufficient to ensure life safety.

Board for the Coordination of Model Codes (BCMC)

The earliest BCMC reports obtained were from 1977; therefore, information on changes prior to 1977 was not available.

Uniform Building Code

The 1943 edition of the UBC did not contain any significant changes from the previous edition; however, a number of changes were made between the 1943 and the 1946 editions. Though it is unclear if this incident had any direct impact, the following were changes incorporated into the 1946 edition of the UBC:

- Required egress width requirements changed to provide one foot of width for every 50 occupants. The previous requirement provide for a varying number of inches of exit width per person based upon the total occupant load;
- A main entrance/exit provision was added such that the main entrance/exit was now required to have a capacity not less than 50% of the design occupant load;
- The number of required exits was changed such that 2 exits were required from 10-499 occupants; 3 exits for 500-999 occupants; and 4 exits for more than 1,000 occupants;
- Panic hardware was now required for doors serving more than 50 occupants in assembly occupancies.

BOCA Building Code (BOCA)
The first edition of the BOCA code was not published until 1950.

Standard Building Code (SBC)
The first edition of the SBC was not published until 1945.

Modeling Efforts

In one study, the Cocoanut grove fire was the subject of a number of modeling efforts. Both CFAST and WPI/Fire were used to model fire effects within the building. FPETool was also used to estimate the evacuation time from the building and to estimate sprinkler activation time (had sprinklers been present).

C.3.9 Winecoff Hotel Fire, Atlanta, Georgia, 1946

In the early morning hours of December 7, 1946 a fire occurred at the fifteen-story Winecoff Hotel in downtown Atlanta [11,12,13]. At the time the hotel had 280 guests in its 194 rooms and 119 of these guests died in the fire. The hotel was advertised as fireproof because of a brick exterior and concrete and steel construction. It was built in 1913 and did not have fire escapes or a sprinkler system because it was not required by code when it was built. The authorities believed that the fire began on the fourth or fifth floor. The fire was reported to the night auditor and as soon as he verified that there was a fire he sounded the alarm around 3:20am. However, the fire department records indicate that the first alarm came in by telephone at 3:42am. The night auditor then contacted as many rooms as possible before the switchboard stopped working telling the guests to keep their doors closed and to stay calm. However, only the rooms on the third through the sixth floors had heavy wooden doors and tightly sealed transoms. Above the sixth floor, the rooms did not have the thick doors and many of the transoms had been permanently opened allowing for smoke and flame to spread into these rooms. Also, the fire spread quickly because it was aided by the open narrow staircase that acted as a flue. The fire was ruled as an accident, caused by a burning cigarette on a mattress. However, there are some investigations that have pointed toward arson.

The following details regarding this incident are of note:

- There were no fire escapes or sprinklers in the hotel;
- There was a twenty minute delay in reporting the fire to the fire department;
- The main central staircase was open and allowed flame and smoke to spread floor to floor;
- Fire rated doors were not used;

- The transoms were not fire rated or sealed.

Impact on Regulation or Practices

The Winecoff fire led to a number of new fire regulations for Atlanta. The major change was to require the enclosing of stairwells with additional requirements for alarm systems and smoke detectors.

The impacts that this incident had on various regulations are discussed below.

NFPA 101®: Building Exits Code®
There do not appear to be any changes to NFPA 101 directly associated with this incident.

Board for the Coordination of Model Codes (BCMC)
The earliest BCMC reports obtained were from 1977; therefore, information on changes prior to 1977 was not available.

Uniform Building Code (UBC)
There do not appear to be any changes to the UBC directly related to this incident.

BOCA Building Code (BOCA)
The first edition of the BOCA code was not published until 1950.

Standard Building Code (SBC)
The first edition of the SBC was not published until 1945. Details of proposed changes and committee reports were not available prior to 1977.

C.3.10 Our Lady of Angels School Fire, Chicago, Illinois, 1958

Inadequate exit components were blamed for the loss of 93 occupants in a fire that spread rapidly through the Our Lady of Angels School in Chicago in 1958 [5]. The school consisted of a pair of two-story brick buildings connected together. However, per the applicable code, the building was considered one fire area, since the masonry wall separating the two annexes did not have protected openings, and the majority of the stairways within the buildings were not enclosed. The actual origin of the fire is not known, but it was located in a rear unenclosed stairway. Combustible materials here, as well as in adjoining corridors, contributed to rapid spread from the stairway to other areas of the building. Additionally, combustible ceiling tiles in the classrooms likely added to fire growth and spread.

After the fire was discovered and efforts were made to locate the school principal, the few teachers aware of the fire evacuated their own classes to another building. Only after returning did they activate the school's fire alarm and initiate general evacuation. Because the fire had moved up the open stairway in which it initiated and was largely burning in the second floor corridor, the first floor occupants were able to evacuate through the five available exit stairs. Some of the upper level occupants were able to escape because someone closed the dividing door between the two annexes, thus largely confining the products of the fire to the North wing. However, occupants of the North wing could not use the corridor to escape because of smoke and heat, and thus were forced to jump from the second-story windows or to be rescued by fire fighters using ladders. The majority of the fatalities occurred in this area.

The following details regarding this incident are of note:

- Only two of the five available stairways were enclosed, and these had inadequate opening protection at their landings. At the time of the fire, the doors to these stairwells were propped open;
- Combustible materials in the stairwell where the fire started, combustible wood trim in the main second-floor corridor, and combustible ceiling tiles in the classrooms all contributed to rapid and widespread fire impact on the second floor of the North annex;
- Notification was delayed because teachers evacuated their own classes before sounding a general alarm. By the time a general evacuation was initiated, dense smoke and heat had reached the upper corridor through the open stairwell. This prevented occupants of the upper floor of the North annex from reaching the enclosed exit stairway at the North end of the corridor;
- The opening protection between the two annexes was substandard, and the door in the upper corridor was propped open leading up to the fire. An occupant closed it during the fire, thus isolating the occupants of the second story portion of the South annex from the heat and smoke of the fire.

Impact on Regulation or Practices

Spurred by the Our Lady of Angels fire, the Los Angeles Fire Department conducted a series of tests designed to explore methods of protecting multistory school buildings containing open stairways. One of the major conclusions of these tests was that automatic sprinkler systems provided the best chance of occupant safety and egress.

Generally speaking, the Our Lady of Angels fire awakened much of the US to hazards present in the country's schools, and efforts were undertaken to improve conditions. One year after the fire, the NFPA polled fire departments regarding fire safety in schools, and it was found that the majority of communities had implemented better fire drill procedures, improved waste control measures, refined inspection requirements, and more appropriate storage of combustible goods;

NFPA 101®: Building Exits Code®

In response to the Our Lady of Angels fire and the Los Angeles fire tests, the NFPA reorganized its provisions for educational occupancies, which included requirements for sprinklers in school buildings of different types.

Board for the Coordination of Model Codes (BCMC)
The earliest BCMC reports obtained were from 1977; therefore, information on changes prior to 1977 was not available.

Uniform Building Code (UBC)
There do not appear to be any changes to the UBC directly related to this incident.

BOCA Building Code (BOCA)

The 1960 edition of BOCA contained changes in the Interior Finish requirements which modifying how material combustibility was classified. It is uncertain if any changes occurred in the requirements for the types of materials allowed in various occupancies.

Standard Building Code (SBC)

The first edition of the SBC was not published until 1945. Details of proposed changes and committee reports were not available prior to 1977.

C.3.11 Upstairs Lounge Fire, New Orleans, Louisiana, 1973

On June 24, 1973, an arson fire killed 32 patrons of the Upstairs Lounge in New Orleans, Louisiana [14]. The fire was started in the only staircase serving the upper floors of the three-story building. The second floor was the lounge, and the third floor included unoccupied apartments. At the time of the fire, there were 65 people in the lounge, which had a capacity of 110. Once established, the fire spread rapidly up the stairwell, fueled by combustible wood paneling and carpeting. The stairway was separated from the lounge on the second floor by a wood-framed partition with plaster-on-lath covering the studs. An approved fire door assembly was installed in this partition. However, on the night of the fire, a patron responding to repeated rings of the doorbell opened this door, and fire rushed into the lounge.

The location of the fire in the exit staircase prevented occupants from evacuating down the main exit stairs. An alternate escape path, opening onto an adjacent building's roof, was located in the back of the lounge, but was not marked as an exit. Also, the path to this door was obstructed by equipment on a stage, and the door had an improvised latch. The bartender attempted to lead people to this door, and was successful in evacuating several people in this fashion. However, on his second attempt to move people to the back door, he received no response, and evacuated, latching the fire door behind him. The final exit option was through the windows of the club. The building was equipped with a single fire escape, accessed through one of the windows. Many windows in the lounge were boarded up; other windows in the bar area were equipped with metal bars to prevent patrons from falling through. This proved to hamper escape efforts. Some occupants were able to squeeze through the bars and reach the outside, where they jumped, slid down drainpipes and other building features, or utilized the fire escape. Many of the fatalities occurred in the bar area in the vicinity of the exterior windows.

The following details regarding this incident are of note:

- The fire spread rapidly up the only stairway in the building due to the combustible interior finishes within the stairwell;
- The fire door at the top of the stairwell, which initially blocked the heat and smoke from the fire, was opened by a patron and, presumably, remained open for the duration of the fire. Smoke and flames entered the lounge immediately after this door was opened, and patrons had little time to react;
- A rear door, which turned out to be the only safe exit, was not properly marked as an exit, and the path to it was hidden and obstructed by a stage and associated equipment. Also, it had an improvised latch, which may have been difficult to operate by those unfamiliar with it;
- Numerous windows were boarded up, and the rest were equipped with steel bars to prevent people falling through the large glass panels. Many of these also had wooden shutters over their lower sections.

Impact on Regulation or Practices

NFPA 101®: Life Safety Code®

There do not appear to be any changes to NFPA 101 directly associated with this incident.

Board for the Coordination of Model Codes (BCMC)

The earliest BCMC reports obtained were from 1977; therefore, information on changes prior to 1977 was not available.

Uniform Building Code (UBC)

There do not appear to be any changes to the UBC directly related to this incident.

BOCA Building Code (BOCA)

While it is unclear if changes were perpetuated by this incident, a number of changes appear in the 1975 BOCA code. Due to the fact that these changes tend to make the Code more lenient, it is doubtful that they were in response to this incident. These include:

- Increases in the egress capacities of doors and stairs as follows:
  - Unsprinklered - 75 people per unit width for stairs and 100 people per unit width for doors;
  - Sprinklered – 113 people per unit width for stairs and 150 people per unit width for doors;
- Before the 1975 edition, the egress capacities for unsprinklered buildings was 60 people per unit exit width for stairs and 90 people per unit exit width for doors;
- Travel distances were increased to 150 ft. for unsprinklered buildings and 200 ft for sprinklered buildings. Before the 1975 edition, the travel distance was 100 feet for all construction types;
- Panic hardware was now required for all assembly occupancies with an occupant load greater than 100 persons;
- Sprinkler systems were now more widely required for various assembly spaces;
- Standpipes were more widely required for assembly spaces with more than 300 occupants.

Standard Building Code (SBC)

The first edition of the SBC was published in 1945. Details of proposed changes and committee reports were not available prior to 1977.

C.3.12 Gulliver's Discotheque Fire, Port Chester, NY, 1973

On June 30, 1974 a fire killed twenty-four people in a nightclub called Gulliver's in Port Chester, New York [15]. Gulliver's was part of a small shopping center on the Connecticut-New York border that also housed a bowling alley, a men's clothing store, and a barbershop. It was a one-story building with a basement. The basement was used for storage, offices and a children's playroom that the bowling alley rented. The fire started in the basement in a children's playroom. The fire was deliberately set.

The dance floor itself was five feet lower than the dining room and had two adjacent sets of stairs leading to the basement and to the dining room. These were the only exits from the dance floor. At approximately 1:00 am people in the service bar area of the basement at the foot of the stairs to the dance floor noticed smoke. Someone called the fire department while someone else notified the bandleader who told people to leave the building. The evacuation was orderly, but within a minute heavy smoke started

coming up the stairs from the basement to the dance floor. Smoke had traveled in the floor joist channels above the playroom into the service bar area below the dining area and then billowed up the stairs leading to the dance floor. Occupants were forced to leave by using the "up" stairs leading to the dining room adjacent to the basement stairs. Even though the stairs were 5 ½ feet wide there was not enough time for the crowd to evacuate and the twenty-four people that died did so of smoke inhalation.

Once the crowd was warned to evacuate there was not enough time to complete evacuation before smoke exposure became a problem. Some of the reasons for the lack of evacuation time were:

- Delayed discovery of the fire, since it originated in the unoccupied children's play area in the basement;
- Lack of a fire-rated wall between the discotheque and the rest of the shopping center;
- Lack of a fire-rated door at the bottom of the stairs from the service bar to the dance floor;
- Lack of occupant load restrictions;
- Exits from the dance floor were not remote from each other.

Impact on Regulation or Practices

NFPA 101®: Life Safety Code®

There do not appear to be any changes to the 1976 edition of NFPA 101 directly associated with this incident. However, this incident is specifically mentioned in a proposal to change the fire alarm / notification system requirement for the 1981 edition of NFPA 101. The proposal as submitted was rejected, but the concepts were accepted toward creating a new requirement for fire alarm / notification systems in assembly spaces with an occupant load greater than 300 persons.

Board for the Coordination of Model Codes (BCMC)

The earliest BCMC reports obtained were from 1977; therefore, information on changes prior to 1977 was not available.

Uniform Building Code (UBC)

There do not appear to be any changes to the UBC directly related to this incident.

BOCA Building Code (BOCA)

While it is unclear if changes were perpetuated by this incident, a number of changes appear in the 1975 BOCA code. Due to the fact that these changes tend to make the Code more lenient, it is doubtful that they were in response to this incident. These include:

- Increases in the egress capacities of doors and stairs as follows:
    - Unsprinklered - 75 people per unit width for stairs and 100 people per unit width for doors;
    - Sprinklered – 113 people per unit width for stairs and 150 people per unit width for doors;
- Travel distances were increased to 150 ft for unsprinklered buildings and 200 ft for sprinklered buildings;

- Panic hardware was now required for all assembly occupancies with an occupant load greater than 100 persons;
- Sprinkler systems were now more widely required for various assembly spaces;
- Standpipes also more widely required for assembly spaces with more than 300 occupants.

Standard Building Code (SBC)
The first edition of the SBC was published in 1945. Details of proposed changes and committee reports were not available prior to 1977.

C.3.13 Beverly Hills Supper Club Fire, Southgate, Kentucky, 1977

Few assembly occupancy fires have been investigated and documented as thoroughly as the one that occurred at the Beverly Hills Supper Club in Southgate, Kentucky, in 1977. This sprawling nightclub had multiple event rooms of varying sizes. On the day of the fire, multiple events were scheduled, including a wedding reception earlier in the afternoon, and a show was in progress when the fire broke out. In total, 2400 to 2800 people were in the building at this time, and 1200 to 1300 of these were in a single event room (the Cabaret Room). The fire initiation, assumed to be electrical in nature, occurred in an unoccupied room where an event had taken place earlier in the day [5,6]. Employees noticed the flames, and attempted to extinguish them using fire extinguishers. The fire was seated in a concealed space within the wall, and the employees' extinguishment efforts were unsuccessful. Largely because of the unsuccessful efforts to extinguish the fire, approximately 15 minutes elapsed between the discovery of the fire and the general notification of the employees and occupants. Additionally, it is reported that some employees were not sure of evacuation procedures, and this may have further delayed notification.

According to witness accounts, the initial evacuation of patrons followed an interesting trend. Employees tended to notify only those patrons for which they were responsible during the normal operations. In other words, a given waitperson might only have notified the people seated at the tables that that person served. This led to delayed notification of some guests in remote parts of the building. Unfortunately, during the performance in the Cabaret Room, the wait staff was isolated from the patrons so as not to interrupt the performances, and thus employees did not instinctively notify occupants in the Cabaret Room. This led to delayed notification within the Cabaret Room; thus, almost all of the 164 fatalities occurred in the Cabaret Room.

Many survivors of this fire owe their lives to a calm and quick-thinking busboy, who took the stage in the crowded Cabaret Room, pointed out the available exits, and asked people to leave. Some followed his advice, but many did not perceive the danger until smoke and heat reached the area outside of the Cabaret Room. At this point, occupants began to rush to the exits. Some tripped or were knocked down, and the exits became blocked. According to the busboy, one of the three available exit doors was locked, and he was unable to break it open.

The following details regarding this incident are of note:

- While the applicable codes of the time limited the occupancy of the club to 1511 based on its construction, more than 2400 occupants were inside at the time of the fire;
- The Cabaret Room was vastly overcrowded, with tables pushed together and additional seating placed in the aisles, thus blocking egress movement. Based on the codes at the time the capacity of the Cabaret Room was just over 500, but there were over 1000 occupants in the room that evening [3];

- The exit capacity of the egress system was approximately 60% of the code-required capacity;
- The Cabaret Room should have had four separate exits, but it only had three, and at least one was locked at the time of the fire. Some of these exits were poorly marked or intentionally masked;
- There was no evacuation plan and personnel were not properly trained;
- Once established in the compartment of origin, fire spread rapidly across combustible interior finish within the room of origin and the main corridor of the building;
- Many occupants did not perceive the severity of the fire until it was too late, and few evacuated immediately upon being told to do so. No alarm system was installed within the building.

Impact on Regulation or Practices

NFPA 101®: Life Safety Code®

According to information in the Life Safety Code® Handbook:

- Previous to the Beverly Hills Supper Club fire, the NFPA 101 Life Safety Code required alarm systems in all occupancies except storage spaces and places of assembly. The reasoning for the latter was that it was felt that an alarm might cause panic. This fire showed the importance of rapid notification, and the next version of the Code, the 1981 edition, included a requirement for alarm systems in places of assembly. Additionally, a note was added requiring that notification of places of assembly be done through a voice alarm or a public address system. These requirements were implemented retroactively in existing buildings, as well;
- The Life Safety Code historically only required sprinkler systems in assembly occupancies when those spaces were used as exhibit halls. After the Beverly Hills Supper Club incident, provisions were added to the 1981 edition of the code requiring sprinkler systems in different assembly occupancies based on the types of construction used. Some of these requirements were also issued retroactively.

Board for the Coordination of Model Codes

There do not appear to be any recommended changes to the model building code from the BCMC as a result of this event.

Uniform Building Code (UBC)

There do not appear to be any changes to the UBC directly related to this incident.

BOCA Building Code (BOCA)

While unclear if changes were directly related to this incident, a few changes appear in the 1978 BOCA code. These include:

- Panic hardware in all assemblies with 50 or more occupants.
- Door swing in the direction of travel when serving 50 or more occupants.

Standard Building Code (SBC)

There do not appear to be any changes to the SBC directly related to this incident.

Modeling Efforts

In the early 1980s Emmons [44] attempted to estimate mathematically fire growing and fire gas spread rate in the Beverly Hills Summer Club fire. Using a resistor network diagram and mean flow volume equations this "educated guess" clearly showed that the act of opening doors to escape drew the fire into the escape routes.

C.3.14 "The Who" Concert, Cincinnati, Ohio, 1979

The Who concert was a sold out show and many ticket holders had arrived to the Coliseum early and were waiting to be let into the venue to claim the best seats. There were over 18,000 general admission tickets sold and as many as 8,000 ticket holders waiting outside competing for the preferred general admission seating [3]. Two banks of eight doors were finally opened, but according to many in the crowd, not all of the doors were opened. The guards would let in people until the lobby was full and then they would temporarily close the doors. This resulted in the crowd pushing forward. Within an area outside one of the banks of doors, several people fell. The people behind those that had fallen were pushed forward by the crowd. The surge toward the Coliseum resulted in eleven people being crushed to death and approximately two-dozen more becoming injured from he incident [17]. Concertgoers told of only one or two doors being open out of a possible sixteen to process the incoming crowd.

The following details regarding this incident are of note:

- Poor crowd safety was the major cause of this tragedy;
- Only a few doors out of a total of 16 were open to accommodate 8,000 people and when the lobby filled the guards closed the doors, which caused the crowd to become concerned about getting into the arena.

Impact on Regulations or Practices

This incident spurred the Cincinnati government to take action. By the end of the month the Mayor and City Council had passed legislation that banned festival seating and gave the police emergency on-the-scene authority at major public assembly venues. In addition, a full-scale investigation was conducted by an independent citizen's task force called "The Task Force on Crowd Control and Safety", which was established by the City Council. The Task Force released a report called Crowd Management in 1980 that offered 108 crowd safety recommendations. The report is now in its fourth printing and remains one of the important manuals on facility rock concert crowd management.

NFPA 101®: Life Safety Code®
A requirement regulating festival seating-type assembly areas was introduced into the code for the 1994 edition.
Board for the Coordination of Model Codes
There do not appear to be any recommended changes to the model building code from the BCMC as a result of this event.
Uniform Building Code (UBC)
There do not appear to be any changes to the UBC directly related to this incident.
BOCA Building Code (BOCA)
There do not appear to be any changes to the BOCA code directly related to this incident.
Standard Building Code (SBC)
There do not appear to be any changes to the SBC directly related to this incident.

C.3.15 Haunted Castle Amusement Facility Fire, Jackson Township, NJ, 1984

On May 11, 1984 a fire destroyed the "Haunted Castle" amusement at the Six Flags Great Adventure Park located in Jackson Township, New Jersey [18]. Eight young adults died as a result of smoke inhalation and carbon monoxide poisoning. The structure was composed of seventeen commercial trailers connected by plywood and wood framing. The interior of the amusement was constructed of plywood partitions creating a convoluted path 450 ft. long. Other materials used in the interior of the structure were synthetic foam, various fabrics and plastics, and tarpaper. The cause of the fire was the accidental ignition of a wall mounted, polyurethane foam pad by a cigarette lighter from a visitor trying to light their way through the dark path. The foam pad burned rapidly and fire spread down the corridor fueled by plywood construction of the ceiling, floor, and walls. The foam was not flame retardant and the plywood was untreated.

At approximately 6:30 PM an employee in the Haunted Castle smelled smoke and went to investigate. Coming upon heavy smoke he went to the main gate to instruct employees to discontinue entry of visitors and then went to the control room inside the facility to call the park fire brigade. Meanwhile, a visitor in the amusement discovered the fire and alerted an employee. There was approximately a five-minute delay between the employee detecting the fire and alerting the fire brigade.

There were a total of seven exits including the main entrance and fire protection features included emergency lighting and portable fire extinguishers. There were no automatic detection or sprinkler systems provided in the facility.

The following details regarding this incident are of note:

- The fire was not detected and suppressed in its incipient stage because of the lack of automatic detection and suppression systems;
- There was a large amount of combustible material present including interior finishes such as foam and plywood;
- The occupants had difficulty escaping due to fire conditions in the haunted house type of environment.

Impact on Regulation or Practices

NFPA 101®: Building Exits Code®

Though unclear if directly related to this incident, the interior finish requirements were changed for the 1985 edition of NFPA 101 so that rooms with an occupant load greater than 300 were limited to Class II interior finish materials. Class III materials were still allowed in rooms with less than 300 occupants.

Board for the Coordination of Model Codes (BCMC)

The BCMC report dated February 19, 1985 included recommendations for the size, location and illumination of exit signs. It is uncertain if these recommendations were directly related to this incident, but they certainly address the pertinent issue of the Haunted Castle fire.

Uniform Building Code (UBC)

Though unclear if directly related to this incident, the interior finish requirements were changed for the 1985 UBC so that rooms with an occupant load greater than 300 were limited to Class II interior finish materials. Class III materials were still allowed in rooms with less than 300 occupants.

BOCA Building Code (BOCA)

There do not appear to be any changes to BOCA directly related to this incident.

Standard Building Code (SBC)

While unclear if directly related to this event, the main exit provision was modified for the 1985 edition of the SBC. The new requirement called for 1/2 of the total egress capacity to be provided through the main exit and 2/3 of the total egress capacity to be provided by all other exits.

C.3.16 Happy Land Social Club Fire, New York, New York, 1990

Early on the morning of March 25, 1990, numerous patrons were in the Happy Land Social Club in the Bronx borough of New York City [20,21]. It is suspected that an arsonist used an accelerant to ignite a fast-growing fire in the building's main lobby, and that combustible interior finish contributed to the rapid growth of the fire. The ground floor of the building, which is where the lobby was located, had been left unsprinklered during a previous renovation, and thus the fire spread unimpeded. Coatroom employees discovered the fire, and alerted first floor occupants. Another employee went up to the second floor, where the majority of occupants were located, to alert patrons to the fire. Only two occupants from the second floor survived, although one of these sustained severe burns running through the lobby to the main exit; these individuals left the second floor immediately upon being informed of the fire. Fire damage was limited to the front portion of the building. A total of 87 people died in this fire, 18 on the first floor, and 69 on the second.

The following details regarding this incident are of note:

- At the time of the fire, the club was in violation of New York City building and fire code regulations, and had been ordered shut down, but was still in operation;
- At some point in its history, the building had been converted from one story (high ceiling) to two, and the original sprinkler system was not extended to the first floor. Also, part of the sprinkler system on the second floor was not functional. The fire initiated in an unsprinklered area;
- One of the two main exit doorways to the front exterior of the building was covered by an unlocked roll-down steel security door. The swinging doors here were locked, and the doorway was not marked from the inside as an exit. However, at some point during the evacuation, an employee unlocked this door, and it was used by several egressing occupants;
- Four additional doors separated patron areas from an entrance lobby. All of these doors swung in the direction of egress travel, but three of the four were locked at the time of the fire;
- The two available exit stairs were not enclosed. The stairway closer to the front exit was a steep "ships ladder" type stair. The primary stair access to the second floor, and the stairway labeled as the main exit, was at the back of the building. This stair had uneven risers, as well as a 90° bend and a width that varied down to 19 inches;

- Combustible interior finishes in the lobby area, where the fire was ignited, led to rapid fire growth, thus blocking the only available exits from the building.

Impact on Regulation or Practices

NFPA 101®: Life Safety Code®

There do not appear to be any changes to NFPA 101 directly associated with this incident.

Board for the Coordination of Model Codes

There do not appear to be any recommended changes to the model building code from the BCMC as a result of this event.

Uniform Building Code (UBC)

Though it is unsure if this incident had any direct impact, the following were changes incorporated into the 1991 edition of the UBC:

- Required egress width requirements changed to provide 0.3 inches of stair width and 0.2 inches of door width for each occupant. The 1946 through 1988 editions of the UBC specified required exit width as the number of occupants divided by 50. However, in the 1943 version of the UBC required 0.24 inches per person for occupancies with 1 to 1000 occupants, which is greater than the width required in 1991;
- A fire alarm / notification system was now required for assembly spaces with and occupant load greater than 300.

BOCA Building Code (BOCA)

The 1993 edition of the BOCA code incorporated changes in the requirements for sprinkler and standpipe system, but it is unclear if there changes were related to this incident.

Standard Building Code (SBC)

There do not appear to be any changes to the SBC directly related to this incident.

C.3.17 Indianapolis Athletic Club Fire, Indianapolis, Indiana, 1992

On February 5, 1992 a fire occurred at the Indianapolis Athletic Club that killed two fire fighters and one patron [22]. At 12:06am the Indianapolis Fire Department received a phone call reporting the fire. Upon their arrival, they could find no external evidence of fire in the high-rise building, but once inside they found heavy smoke in the first floor lobby. Investigating further, they discovered a room on the third floor that was fully involved in fire. During suppression operations on the third floor, a flashover occurred in the room adjacent to the room of fire origin. The sudden increase in the magnitude of the fire caused it to spread to other areas and resulted in the death of two fire fighters. Several other fire fighters were injured. A search of the building revealed that one patron died in the fire between the sixth and seventh floors.

The fire department determined that the fire was accidental and caused by an electrical fault involving a refrigerator caused the ignition of wood paneling in a third-story bar. It was further determined that the release of combustion gases which were trapped in a concealed space contributed to the flashover that killed and injured the fire fighters. After the flashover, the fire spread to other areas of the third floor and it also spread to the fourth floor via an open stairway. The HVAC systems also continued operation until electrical power was lost and contributed to the spread of smoke throughout the building.

The following details regarding this incident are of note:

- The lack of an approved automatic sprinkler contributed to the spread of the fire;
- Unprotected penetrations in the wall and ceiling assemblies aided the fire spread;
- Concealed spaces increased the hazard for fire suppression personnel;
- Combustible interior finish which included wood paneling on walls and ceiling tiles left in concealed spaces after a building renovation also contributed to the magnitude of the fire.

Impact on Regulation and Practices

NFPA 101®: Building Exits Code®

There do not appear to be any changes to NFPA 101 directly related to this incident.

Board for the Coordination of Model Codes (BCMC)

There do not be any recommended changes from the BCMC directly relating to this event.

Uniform Building Code (UBC)

There do not appear to be any changes to the UBC directly related to this incident.

BOCA Building Code (BOCA)

Changes to the automatic sprinkler requirements appeared in the 1993 BOCA code. Sprinkler system were now required as follows:

- In A-1 (theaters), A-3 (amusement / entertainment spaces), and A-4 (churches / schools) where the fire area exceeds 12,000 ft²;
- In A-2 (dance halls / clubs) where the fire area exceeds 5,000 ft² or is located above or below the level of exit discharge.

It is uncertain if these changes are directly related to this incident.

Standard Building Code (SBC)

There do not appear to be any changes to the SBC directly related to this incident.

C.3.18 E2 Nightclub, Chicago, Illinois, 2003

In the early morning hours of February 17th, 2003 21 people were killed and 57 people were injured when a stampede occurred at the E2 nightclub in Chicago [23]. A fight had broken out on the dance floor between two women and escalated to include a larger group. Security guards sprayed pepper spray into the crowd triggering a stampede toward the front exit. The nightclub is located on the second floor of the building, so the front exit was a set of stairs leading down to the main exit door. The surge toward the main exit stairway resulted in the deaths of 12 women and 9 men. Most of the deaths occurred at the top of the stairs.

The nightclub was on the second floor of a building. There was a restaurant on the first floor of the building that housed the nightclub that was not open at the time of the incident. The club had been ordered closed due to fire and structural building code violations months before the incident. However, the Chicago Fire Department estimated that 500 people were in the building that night.

The following details regarding the incident are of note:

- The club should have been closed due to numerous building code violations;
- Alternate exits were not easily assessable to the patrons [24];
- A consultant hired by the lawyers representing some of the victims and their families found 20 code violations including that the two rear exit signs were not lighted and based on the width of the exit doors the second floor of the building could safely handle 240 to 300 people, which would mean that the club was overcrowded since the FD estimated there to be 500 occupants at the time [25];
- Although the violations involving the back exit doors did not contribute to the deaths, one of the back doors was locked and another was partially blocked by laundry bags.

Impact on Regulation or Practices

It is too early to determine how or if the building codes will be impacted by the E2 incident.

C.3.19 Summerland Fire, Isle of Man, United Kingdom, 1973

On August 2, 1973 a fire broke out in a kiosk outside the Summerland entertainment complex on the Isle of Man and killed 51 people [26]. It is believed that adolescents smoking in the kiosk started the fire. The burning kiosk fell against the adjacent building and ignited the outside of the building. The building was clad with combustible transparent acrylic sheeting called Oroglaso. When ignited, the material became molten and dripped on the people trying to escape. In addition to the combustible exterior, there was a flammable material used to line the inner walls for soundproofing purposes. These materials caused the fire to spread rapidly.

Upon hearing of the fire, people began to leave, but an employees told the crowd that it was just a chip-pan fire and that there was no need to worry. Some of the people returned to their seats. It took the staff twenty-five minutes to contact the fire brigade. Later the fire burst into the building and the evacuation of the building became pandemonium. Emergency doors had been padlocked and there were turnstiles that could not handle the amount of people evacuating.

The following details regarding this incident are of note:

- It took twenty-five minutes for the staff to notify the fire brigade;
- Combustible exterior sheeting as well as combustible interior finishes aided fire spread;
- Emergency doors had been padlocked;
- There were turnstiles that could not handle the size of the crowd.

Impact on Regulation or Practices

The aftermath of Summerland fire led to the tightening of fire regulations on public buildings across the Isle of Man and the United Kingdom.

C.3.20 Stardust Cabaret, Dublin, Ireland, 1981

In the early morning hours of February 14th, 1981, a fire spread through the Stardust Cabaret in Dublin, killing 48 young people and seriously injuring 128 [27]. It was originally intended that the building be used for cabarets and concerts, but it was subsequently used as a disco. The space consisted of a dancing area, a small stage, and two seating areas. The fire started in the back row of one of the seating areas. The fire spread rapidly from seat to seat in the area of origin and ultimately through the entire area due to

the presence of a tier of seats containing quantities of combustible material abutting a wall lined with combustible carpet tiles, the presence of a low ceiling, and the presence of a large area of combustible seating. Although there were eight exits from the ballroom, five of these being principal emergency exits, forty-eight young people died because of the rapid fire spread. The investigation concluded that the fire was set deliberately and that the arsonist aided the fire spread by slashing the seats and igniting them or by lighting newspapers under a seat.

There was adequate exit capacity in the Stardust, but the fire spread rapidly, resulting in the large death toll. Combustible seating and interior finishes aided the fire spread.

Impact on Regulations or Practices

The Irish Government established a Tribunal to carry out a full investigation of the fire. The Tribunal made a significant range of recommendations that were examined by the Irish authorities. However, it was not confirmed whether the Stardust fire led to changes in regulation.

C.3.21 Dance Hall Fire, Gothenburg, Sweden, 1998

During a Halloween party in 1998 at a second-floor dance hall in Gothenburg, Sweden, an arsonist initiated a fire in one of the two available exit stairways [28]. The fire spread through the stairwell, fuelled by combustible furniture and wall coverings within the stairwell. At the time of the fire, approximately 400 people were in the hall. Based on the size of the hall and the available exit door width, US codes of the time would have limited the occupant load to 312 people. The local fire brigade has indicated that, based on the exit door width, they would have limited the occupant load to 150.

The dance hall was equipped with two separate exit doors at opposite ends of the space. Each exit door swung in the direction of egress travel. The main entrance/exit door was noncombustible, and was equipped with an automatic closer. The other door was constructed of combustible material, but had a 30-minute rating, and was equipped with an automatic closer. Because the fire was located in this second stairway, it was not used in the evacuation. It is not clear if this door remained open after the discovery of the fire. Both doors had an opening width of 31.2 in.

The large number of people in the yard surrounding the building hampered fire department access to the incident. Once inside the main entrance of the two-story building, firefighters discovered numerous victims on the stairway leading to the second floor. These victims were removed, and firefighters continued to the second floor, where the discovered a stack of additional victims in the exit doorway from the main hall. Victims, some alive and others unconscious were apparently stacked right up to the top doorjamb. As firefighters pulled the occupants out, others from inside the hall took their places on the pile. Eventually, the doorway was cleared, and the fire was quickly extinguished. Additional victims were later discovered in a small office where they had attempted to seek refuge when the discovered that the exit was blocked. Smoke had breached this room through failed glass panels near the ceiling.

An occupant-use fire hose was available in the main entrance stairwell, but was not used. Its condition prior to the fire was not known. The building was not equipped with an alarm system or sprinklers.

In total, 63 people died in this incident. None were older that 20 years. 43 of the victims were found piled up at the exit doorway. Another 20 victims were found in a small office. An additional 180 people were injured in the incident.

The following details regarding this incident are of note:

- Fire growth and spread was somewhat rapid due to the fuel loads within the stairwell where the fire was initiated and in the dance hall itself;
- The hall was severely overcrowded, and even though two remote exits were provided, the sheer number of evacuating occupants caused a bottleneck in the one available exit door. It has been theorized that the exit capacity would have been sufficient had the occupant load restrictions been enforced;
- The building was not equipped with a fire alarm or an automatic sprinkler system;
- The occupant (the disc jockey) who first discovered the fire apparently immediately jumped out of a window, and did not notify the other occupants of the fire. It is unclear how much of a delay occurred between initial discovery of the fire and the commencement of a general evacuation;
- Numerous people jumped from the high windows, 20 ft above the ground level. These windows were over 7 ft above the floor level in the dance hall, and were not viable exits;
- Fire brigade arrival at the scene and access to the building were hampered by the crowds of people in the yard surrounding the building. Additionally, there were reports of assaults on firefighters, both in and out of the building, as they attempted to rescue occupants.

Impact on Regulation or Practices

There was some discussion after the investigation of the fire in relation to code requirements for public halls and auditoria. For example, it was questioned whether multiple "normal" exit door widths (0.8 m.) might be better than fewer wider exits (≥1.2 m.) and whether the requirements for the floor surface hazard properties should be made more strict.

Note that these discussions were related to public halls and auditoria. The "dance hall" in Gothenburg was not designed for this purpose and would hence not technically have been affected by such changes.

C.3.22 De Hemel Fire, Volendam, The Netherlands, 2000/2001

A fire occurred during a New Year's eve celebration in a 125 m^2 (1346 ft^2) café on the top floor of a three story building in The Netherlands [46]. Of the approximately 300 people present, fourteen died, primarily from smoke inhalation, and 200 were injured when the fire spread very rapidly through fir branches attached as holiday decorations to the ceiling of the café. Ignition of the branches occurred immediately when a sparkler held above the head of one of the patrons accidentally came in contact with the decorations. The fire quickly overpowered any attempts to extinguish it. There were two exits available from the café, but they were not obviously marked, and in any case, because the fire spread so rapidly, the exit doorways became blocked by those trying to escape.

Two recommendations were made by TNO [46] as a result of their investigation into the fire:

- to provide an organization that can learn from the mistakes already made (nationally and internationally)
- to increase awareness of the dangers of using flammable materials and the need for sufficient escape routes

C.4 DETAILS OF SUCCESSFUL INCIDENTS

C.4.1 School Fire, California, 1992

A grease fire ignited on a stove in the home economics classroom of a single story 4,800 square-foot school building of unprotected ordinary construction [30]. There was a delay in the activation of the alarm system because of a nonfunctioning smoke detector and failure of school personnel to use manual alarms. The students and staff were able to safely evacuate but the fire impinged on the room's ceiling. Personnel saw smoke coming from the classroom and investigated but failed to initiate the alarm system. Building personnel attempted to extinguish the fire with portable extinguishers but the fire re-ignited.

The fire department arrived and the building was still occupied by approximately 1,000 students and staff. The fire department ordered the evacuation by the manual fire alarm system and extinguished the fire. The damage to the building was estimated to be $2,500 and there were no injuries because there were a limited number of students in the involved section.

The following details regarding this incident are of note: the smoke detection failed and there was a delayed evacuation of the building, but there were no injuries because of the limited number of occupants in the area of the fire.

C.4.2 Nightclub Fire, Texas, 1992

At about 12:30 am on a weekend evening, a short circuit occurred in suspended sound equipment on the second floor of a crowded two-story nightclub occupied by hundreds of patrons [31]. The building was 10,000 square foot building of unprotected, noncombustible construction that was located in a mall and housed a two-story nightclub. The automatic sprinkler system operated immediately and quickly extinguished the fire, but smoke and water forced an evacuation of the building.

The fire department arrived and found that four sprinklers had operated and extinguished the fire. Damage was limited to the electrical equipment and was estimated to be $150,000. Several of the occupants were treated for minor smoke inhalation but none were transported to a hospital.

The following details regarding this incident are of note: four sprinklers quickly extinguished the fire and allowed for occupants to safely escape.

C.4.3 School Fire, Oregon, 1992

An 11-year-old child set a fire in a closet of an unoccupied classroom. The fire quickly spread to the attic space of the building [32]. There were 450 students present when the fire occurred. It was discovered by a passerby and a teacher almost simultaneously. The teacher activated the manual evacuation alarm that alerted students and staff to evacuate the building.

The building was constructed in several stages during the 1940's with a total of 37,500 square feet and consisted primarily of wood-frame components. The building was designed so that it circled an interior courtyard on three sides. In 1975, a partial sprinkler system was installed that covered common hallways and areas above classroom doors but there were no other suppression systems installed in the building.

Damage to the building was limited to the attic area and to classrooms below sections where the roof and ceiling collapsed. There were no injuries to students and staff during the evacuation.

The following details regarding this incident are of note: the fire was started in a closet and quickly burned into the attic; the ceiling assembly provided protection to occupants as they escaped.

C.4.4 School Fire, Massachusetts, 1992

Fireworks ignited a fire on the roof of a regional high school after an outside assembly for graduating students had begun [33]. A school official climbed to the roof and discovered an intense fire that involved the roof covering. An attempt was made using portable extinguishers before the fire department was notified, which delayed the response.

The fire department limited and prevented the fire from spreading to the interior, which was confined to the tar and rubber covering of the built-up roof of brick, block, concrete and steel building. There were no injuries that resulted from the incident or the evacuation of the occupied school.

The following details regarding this incident are of note: an exterior fire on the roof required the evacuation of the school; the building materials prevented the fire from spreading to the interior of the building.

C.4.5 School Fire, Oregon, 1994

A fire occurred in a two-story middle school that was constructed of unprotected wood framing and a brick veneer on the exterior [34]. The school's automatic smoke detection system alerted students and faculty of an electrical fire that started in the ceiling and roof voids. The building was not equipped with a sprinkler system but the detection system was connected to an automatic dialer, which notified the fire department.

The fire department found the blaze in concealed wall voids and in the attic where it was spreading laterally over the classrooms. Firefighters made a trench cut, which helped stop the spread of fire. The fire was confined to one wing of the building and limited damage to classrooms, offices, lockers, and a bathroom. An investigation determined that an electrical conduit in the wall void that was placed directly against wood shiplap siding had heated the siding over a period of time. It eventually ignited at a spot level within the ceiling. There were no injuries.

The following details regarding this incident are of note: fire occurred in a concealed space but a smoke detection system notified the occupants of the hidden danger.

C.4.6 Restaurant Fire, Indiana, 1996

A grill fire damaged a restaurant when the flames spread to the ductwork and then to the concealed attic space [35]. The fire occurred in a single story 3,200 square foot facility that was constructed of unprotected, wood-frame construction. The building did contain a localized dry chemical system that was installed in the hood over the grill.

The cook dropped a plastic container filled with an oil-based marinade on to the hot grill. The plastic container melted and the marinade ignited, which caused flames to flare up toward the hood and ductwork. The fire spread to the concealed attic space before the suppression system could be activated. An employee immediately called the fire department, which arrived to find flames extending from the roof ducts. Firefighters surrounded the building and prevented spread to two adjacent buildings. There were no injuries during the fire.

The following details regarding this incident are of note: an accidental fire occurred on the grill and spread to the attic space in an unprotected building that did not injure any occupants.

C.4.7 Dinner Theater Fire, Florida, 1996

A fire occurred in a two-story, 20,000 square-foot building that was constructed of concrete walls and floors with unprotected steel roof with metal deck and built up roof covering [36]. The building contained a wet-pipe sprinkler system throughout, which was monitored by a central station alarm company.

During a performance, someone fired a pyrotechnic device that ignited a burlap net attached to a curtain. The net ignited and smoke began to fill the auditorium that contained 400 children and teachers. Four sprinkler heads were activated that extinguished the fire. Almost simultaneously, an occupant and the alarm company notified the fire department that arrived to find the safe evacuation of the children and teachers.

A majority of the loss of the contents was due to water damage to electronic equipment. There were no injuries to the occupants of the facility.

The following details regarding this incident are of note: a pyrotechnic device ignited materials on the stage that was controlled by sprinklers. The 400 children and teachers were able to safely evacuate the auditorium without injury.

C.4.8 Restaurant Fire, Michigan, 1996

A fire occurred in a single story 3,000 square-foot, single-story restaurant that was constructed of wood framed walls and a wood truss roof deck [37]. The building had no detection system or sprinklers but there were portable extinguishers installed in the building.

An employee in the storage/break room area was waiting for her shift to start and noticed flames coming from the top of a cooler/freezer. She alerted other staff members, notified the fire department and evacuated patrons. An unsuccessful attempt was made by another employee to extinguish the fire using a portable extinguisher.

The fire department arrived to find heavy smoke coming from the restaurant. The fire had spread to the concealed ceiling spaces and the wood trusses. Investigators believe the controls located at the top of the cooler/freezer malfunctioned, starting the fire. The restaurant was destroyed, but there were no injuries during the blaze.

The following details regarding this incident are of note: a malfunctioning cooler/freezer sparked a fire that destroyed the restaurant that was discovered by an employee. There were no injuries during the evacuation, but the building was destroyed.

C.4.9 Community Center Fire, Pennsylvania, 1997

An fire of electrical origin broke out between the fourth and fifth floors of a religious community center [38]. The building was five-stories tall and had a footprint of 10,000 square feet that contained a religious community center, a school and a synagogue. The building was constructed with heavy timber with exterior brick walls and a wooden roof deck that contained a built-up roof covering. There were smoke detectors and manual pull stations located throughout the building along with a partial sprinkler system in a second floor day care center.

There were nearly 100 staff members and students present when an occupant discovered a fire who activated a manual pull station. A central station notified the fire department while the occupants began to evacuate. The fire was confined to the fourth and fifth floors of the auditorium.

An investigation determined that the fire started in a fault in the wiring of a HVAC unit that ignited the structural framing in the concealed void between the fourth floor ceiling and the gymnasium roof. Two firefighters and two civilians were injured.

The following details regarding this incident are of note: an electrical fault in a community center lead to the injuries of two civilians and two firefighters along with extensive damage to two floors of the structure.

C.4.10 Restaurant Fire, Massachusetts, 1997

A fire occurred in a 7,200 square-foot restaurant that was located in a one-and-a-half-story shopping mall located in Massachusetts that was constructed of unprotected noncombustible construction [39]. There were 25 occupants present when a fire in a portable chicken broiler, which was installed after the fire department inspection and was not protected by the chemical suppression system that protected all of the cooking surfaces ignited. All of the occupants safely evacuated the building.

The burners ignited a grease buildup in the bottom of the broiler cabinet. The central station that monitors the wet-pipe sprinkler system received an alarm and notified the fire department. On arrival of the fire department they found a sprinkler located above the cabinet had extinguished the blaze.

The following details regarding this incident are of note: sprinklers extinguished the fire before arrival of the fire department and occupants were assisted with their evacuation.

C.4.11 School Fire, California, 1998

A fire occurred in an unoccupied classroom of an 8,800 square foot, eight-classroom school in California [40]. The fire spread in the attic and concealed spaces between the ceiling and roof of this single story elementary school that consisted of unprotected wood framing with a stucco exterior. The building did not have a fire detection system or sprinklers and the manual fire alarm was out of service when the fire occurred.

The fire is believed to have been started by a short circuit or a circuit overload in fixed wiring in the attic. Teachers had reported several electrical malfunctions in the past prior to the fire. The discovery of the fire by a student lead to the notification of the fire department who arrived to find flames coming from the building's roof and that two of the classrooms were fully involved. The fire spread horizontally because of the lack of fire stops and then burned through the ceiling to the classrooms below igniting the heavy fuel load. There were no injuries to the occupant during the fire.

The following details regarding this incident are of note: a lack of a detection system and the unoccupied classroom allowed for the fire to grow within the attic space, but the ceiling assembly protected the occupants.

C.4.12 Casino Fire, Nevada, 1998

A fire started from unknown causes on the roof behind the casino's façade and then spread through the roof and down through the structure of a three-story casino and hotel [41]. The building was constructed with noncombustible construction and had a ground floor area of 30,000 square feet. The building had a complete-coverage heat and smoke detection system but there were no devices located in the area of

origin of the fire. Additionally, there was a complete-coverage wet pipe sprinkler system but was not effective because it did not extend to the area of origin of the fire.

The fire spread was too rapid to allow for extinguishment by handheld extinguishers but was limited to the casino by a firewall and doors that connected the hotel and casino. One civilian was injured.

The following details regarding this incident are of note:

- A fire occurred in the façade and roof area that burned for a significant time in a concealed area before notification of the fire department.
- The area of origin did not contain any suppression or detection devices.

C.4.13 Restaurant Fire, New Jersey, 1998

A three-story restaurant sustained substantial damage as a result of a fire caused by carelessly discarded smoking materials [41]. The restaurant was built partially over a pier and the fire broke out under the pier. The fire spread up the side of the restaurant to a breezeway, and then moved into the kitchen above a drop ceiling. The restaurant was constructed of protected, wood-frame construction.

A full-coverage smoke detection system activated and prompted evacuation. A partial wet-pipe sprinkler system also activated, but it could not control the fire. There was also a partial-preaction system under the pier that activated and prevented the fire from spreading along the underside of the pier. At the time of the fire the restaurant was in full operation and was hosting several parties. There were no injuries to occupants, but two fire fighters were injured.

The following details regarding this incident are of note:

- The smoke detection system activated and initiated evacuation of the building, so that no occupants were injured.
- The partial sprinkler system could not control the fire and the fire spread above the sprinklers.

C.4.14 Restaurant Fire, Michigan, 1998

A fire initiated in a broiler exhaust hood and then spread to concealed spaces during the operation of the restaurant [41]. The fire occurred in a two-story, unprotected wood-frame structure that had no fire or smoke detection or suppression system. There was a dry chemical extinguishing system that protected the exhaust hood system.

An employee smelled smoke in the kitchen and found a fire in the baffle filters over the operating broiler. After the discovery of the fire the patrons were evacuated and the fire department was notified. Initially, two employees were able to control the fire using portable extinguishers but on the arrival of the fire department there was heavy smoke showing from the vents over the kitchen. The fire spread to the roof/ceiling space and could not be extinguished by the fire department.

An investigation found that the fire originated in a broiler exhaust stack. The fire caused the supports to fail, which allowed the connections in the ductwork to fail and the fire to spread to the void and roof. There were no injuries to the occupants.

The following details regarding this incident are of note:

- The fire occurred in a concealed space that protected the occupants but lead to the discovery of a significant fire that was not easily extinguishable.
- There was a delay of the activation of the dry chemical system protecting the exhaust hood system because the blower was drawing heat and flames away from the fusible links in the hood.

C.4.15 Theater Fire, Nevada, 1999

A fire broke out in the showroom/theater of a large 17-story hotel and casino [41]. The building was equipped with an automatic sprinkler system and smoke exhaust system. Staff noticed flames spreading up the drapes near the stage. Two employees attempted to pull the drapes to the floor while other staff activated the safety evacuation plan.

Firefighters arrived within five minutes to find the evacuation of the theater and the fire that was extinguished by the sprinklers. The smoke exhaust system was used which limited smoke damage. The fire department evaluated five employees for minor smoke inhalation.

An investigation of the fire determined that the fire began near a television monitor that was plugged into an electrical receptacle outlet. The components did not show any signs of fault but a similar monitor located on the other side of the stage had decorative drapes, which had a gold metal base that conducted electricity. The plug was not completely inserted into the receptacle and energized the hanging fabric.

The following details regarding this incident are of note: sprinklers extinguished the fire while employees activated the safety evacuation plan, which led to the successful evacuation of the theater.

C.4.16 Fine Line Music Café, Minneapolis, Minnesota, February 13, 2003

On February 17, 2003 the warm-up band was playing its encore when it set off a pyrotechnic display [43]. This started a fire in the ceiling of the club about 7:15 pm with an estimated crowd of 120 present in the building. The employees had just reviewed safety procedures the previous day and were quick and effective during the evacuation process. All of the occupants escaped and the fire was extinguished by the building's sprinklers within 15 minutes.

The Fine Line Music Café has a capacity of 720 people and occupies a 100-year-old Consortium Building located at 318 1st Avenue North in the warehouse District of Minneapolis, MN. No one was injured in the incident.

The following details regarding this incident are of note:

- The club had a sprinkler system and staff had reviewed the safety procedures the day before the event.
- All of the occupants were outside of the building when the fire department arrived.

C.5 REFERENCES FOR APPENDIX C

[1] Heary, Monica, *Theatre of Death*, The Daily Telegraph, Sydney, Australia, 26 June 2001.

[2] Chicago Public Library, "1903, December 30: Iroquois Theater Fire".

[3] Chertkoff, Jerome M. and Kushigian, Russell H., *Don't Panic: The Psychology of Emergency Egress and Ingress*, Praeger Publishers, Westport, CT.

[4] McGunagle, Fred, *Horror in Collinwood; 172 Students Die in City's Worst Disaster*, Plain Dealer, Cleveland, Ohio, 29 March 1998.

[5] Coté, Ron. *Life Safety Code Handbook, Eighth Edition*, Supplement 1 (Paul E. Teague, M.A.). National Fire Protection Association, Quincy, MA, 2000.

[6] Daily Mining Gazette, "Italian Hall Confession", March 16, 1982.

[7] Callahan, Kevin. "Survivor Remembers Clinic Fire," *Plain Dealer*, Cleveland, Ohio, May 13, 1994.

[8] McGunagle, Fred. "123 Die in Clinic Disaster; Poison Gas Seeps into System; Explosion Rocks Building," *Plain Dealer*, Cleveland, Ohio, 23 August 1998.

[9] NFPA Fire Investigation Report, *Dance Hall Fire (Rhythm Club), Natchez, MI*, April 23, 1940. As published in: "The Natchez Dance Hall Holocaust." *NFPA Quarterly*, 34 #:70-75. 1940.

[10] Second International Conference on Fire Research and Engineering. Gaithersburg, Maryland, USA. 3-8 August 1997.

[11] Brownlee, Ken. *A Date 'Living in Infamy' Fire Years Later; The Winecoff Hotel Fire, Atlanta, Dec. 7, 1946* Claims Magazine, December 2002.

[12] Morehouse, Macon. "Focus on Winecoff Fire," *The Atlanta Journal and Constitution*, Atlanta, Georgia, December 6, 1996.

[13] Soto, Lucy. "Memories of Fear and Destruction," *The Atlanta Journal and Constitution*, 6 December 1993.

[14] NFPA Fire Investigation Report, Night Club Fire (The Upstairs Lounge), New Orleans, LA, June 24, 1973. As published in: "Upstairs Lounge Fire," A. Elwood Willey, *NFPA Journal*, 68 #1: 16-20. 1974.

[15] Lathrop, James K., *Discotheque Fire Twenty-Four Dead*, National Fire Protection Association, Quincy, MA, 1974.

[16] NFPA Fire Investigation Report, Beverly Hills Supper Club Fire, Southgate, KY, May 28, 1977. Includes: "Tragedy in Kentucky," Robert L. Best, *Fire Journal*. (1978) 72#1:21, 36-40; "Comparing the Club with the Code." *Fire Journal*. (1978) 72#1:21, 36-40; "Human Behavior in the Beverly Hills Fire," Joseph A. Swartz, *Fire Journal*, (1979) 73#3:73-74, 108.

[17] Wertheimer, Paul L., *"The Who" Rock Concert Tragedy: When Rock Concert Crowd Management Came of Age*, Engineering for Crowd Safety, 1993.

[18] Bouchard, John, NFPA Investigation Report, National Fire Protection Association, Quincy, MA, 1984.

[19] International Conference on Fire Research and Engineering. Orlando, Florida, USA. September 10-15, 1995.

[20] *NFPA Alert Bulletin*, "Social Club Fire Bronx, New York". Number 90-2, May 1990.

[21] "Arson Suspected as 87 Die in New York Disco Blaze". *The Independent* (London). March 26, 1990.

[22] Isner, Michael, *Fire Investigation Report: Private Club Fire*, National Fire Protection Association, Quincy, MA, 1992.

[23] Johnson, Mark, *Chicago Club had been told to Close*, Milwaukee Journal Sentinel, 18 February 2003.

[24] Reed Business Information US Staff, *Disasters Offer Lessons for Future*, Consulting-Specifying Engineer, 1 March 2003.

[25] Ciokajlo, Mickey and Deardorff, Julie, *Expert Finds E2 Violations*, Chicago Tribune, 20 February 2003.

[26] Carter, Helen. "Isle of Man's Forgotten Holiday Horror." *The Guardian*, London, August 2, 2003.

[27] Pigott, Pierce T. "The Fire at the Stardust, Dublin: The Public Inquiry and its Findings," *Fire Safety Journal*, #7, 1984.

[28] *NFPA Fire Investigation Report, Dance Hall Fire, Gothenburg, Sweden*, National Fire Protection Association, Quincy, MA, 1998.

[29] Jiang, H. et. al. "The Use of Evacuation Simulation, Fire Simulation and Experimental Fire Data in Forensic Fire Analysis." Pedestrian and Evacuation Dynamics 2003: Proceedings of the 2nd International Conference. Greenwich, Uk. Ed. Galea, E. R.

[30] "Firewatch: Students, Staff Evacuate Safely Despite Delay in Alarm." *NFPA Journal*. November/December 1992.

[31] "Firewatch: Sprinklers Extinguish Fire in Crowded Nightclub." *NFPA Journal*. November/December 1992.

[32] "Firewatch: 11-Year-Old Ignites $1 Million Fire." *NFPA Journal*. March/April 1992.

[33] "Firewatch: Student Prank with Pyrotechnic Device Ignites School Roof." *NFPA Journal*. July/August 1992.

[34] "Firewatch: Detectors Alert Occupants to Fire in School." *NFPA Journal*. September/October 1994.

[35] "Firewatch: Grill Fire Damages Restaurant." *NFPA Journal*. September/October 1996.

[36] "Firewatch: Sprinklers Extinguish Fire in Occupied Dinner Theater." *NFPA Journal*. March/April 1996.

[37] "Firewatch: Fire Destroys Restaurant, Patrons Evacuate Safely." *NFPA Journal*. May/June 1996.

[38] "Firewatch: Electrical Fire Damages Community Center." *NFPA Journal*. September/October 1997.

[39] "Firewatch: Sprinkler Controls Grease Fire." *NFPA Journal*. July/August 1997.

[40] "Firewatch: Fire in Concealed Space Damages Occupied School." *NFPA Journal*. January/February 1998.

[41] "1998 Large Loss Fires and Explosions." *NFPA Journal*. November/December 1999.

[42] "Firewatch: Drapes Ignite in Theater." *NFPA Journal*. May/June 1999.

[43] Chanen, David. Warm-up act sets Fine Line afire; No one hurt; club has heavy water damage. Star Tribune. Minneapolis,

[44] Emmons, Howard. 'Analysis Of A Tragedy'. Harvard University, Cambridge, Ma. *Fire Technology, Vol 19*, No. 2, 115-124, May 1983.

[45] "Evaluation of Limitations to Egress through Doorways in Emergency Situations," vol. 1, Ove Arup & Partners Massachusetts Inc., Job number 32979, Westborough MA, February 18, 2004.

[46] Lostetter, S.M.O., and Reijman, P.B., "Reconstruction of the Fire in 'de Hemel' in Volendam, New Years Eve 2000/2001," Interflam 20